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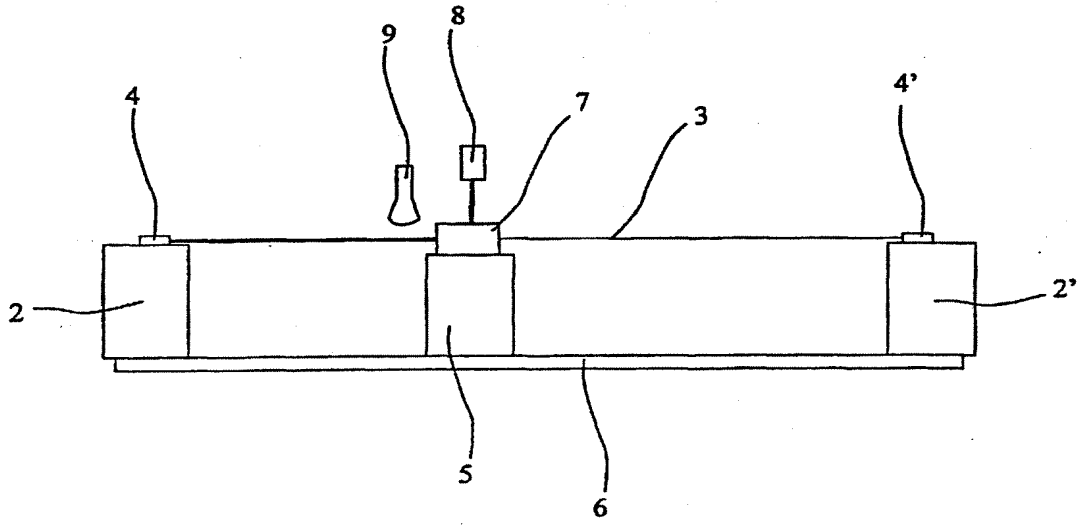

(57) Abstract: Device for coating an optical fibre component (3) from which the external coating has previously been removed, comprising: a mould (7) for coating the said component, a pair of fixing elements for retaining the said component in a rectilinear position, a device for the movement of the said mouold (7) and the said optical fibre component (3) relative to each other, which enables the mould to pass along the whole length of the component placed in a rectilinear position.

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METHOD AND DEVICE FOR COATING AN OPTICAL FIBRE COMPONENT

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DESCRIPTION

The present invention relates to a method for restoring the coating on a portion of optical fibre from which the original coating has previously been stripped.

Optical fibres for telecommunications are produced in equipment for producing optical fibres from a preform containing silica, which is typically the material suitable for the fabrication of an optical fibre.

The equipment comprises a furnace designed to heat an end portion of the silica-based preform, having a diameter in the range from approximately 2 to approximately 12 cm. Downstream of the furnace there are placed drawing means designed to draw an optical fibre from the end of the preform along an axis of advance at a predetermined speed.

The equipment is provided, between the furnace and the drawing means, with a device for cooling the fibre, designed to regulate the temperature of the said fibre at the entry to a first coating station, where a first layer of protective film is applied, this film typically consisting of an acrylic resin (the presence of the cooling device is above all particularly advantageous in high-speed spinning processes). Downstream of the first coating station there are provided a UV furnace for curing the applied resin and another pair consisting of a coating station and a UV furnace, designed, respectively, for the application and curing of a second layer of protective film, which also typically consists of an acrylic resin.

Downstream of the furnace there is placed a twisting device capable of imparting a torque about the axis of advance to the coated optical fibre. The equipment also comprises, downstream of the drawing means, a reel for collecting the optical fibre which is produced.

Patent application 98EP-202098.4 in the name of the present Applicant describes this equipment in detail.

The acrylate coating typically has an external diameter of 250 μm, different from the 125 μm diameter of the fibre, and has the purpose of:

- imparting better mechanical characteristics to the fibre;
- preventing the fibre from coming into contact with the air.

For the purposes of the present invention, the term "bare optical fibre" denotes a fibre without both of the said coating layers; in other words, one whose outermost layer is the cladding.

A fundamental factor in the production of an optical fibre is the achievement of a high concentricity of the bare fibre and the coating, since the protection imparted by the coating must be uniform over the whole length of the fibre, and, owing to the very small dimensions of the fibre, is a highly critical factor in the production of optical fibres.

In order to be able to carry out certain types of processing on the fibre, the coating of the fibre must first be removed; the coating must be restored later, after the processing has been completed.

One example of processing of optical fibres which requires the removal of the coating is the formation of a joint between two end portions of optical fibres, in other words an operation of welding the said two portions together.

A further example of processing of optical fibres which requires the removal of the coating is the writing of a periodic grating, in other words a set of wavelength-selective mirrors, in the fibre; this is done by modulating the refractive index of the fibre core by means of UV radiation.

For the purposes of the present invention, an "optical fibre component to be coated" is defined as being a portion of bare optical fibre, a joint between two terminations of optical fibres, or a portion of optical fibre from which the coating has been removed, on which work has been done to produce an optical fibre component, for example a periodic grating.

In both these cases, the part of the fibre from which the original coating (in other words, that deposited immediately after the spinning of the fibre) has been removed is not more than 5-7 cm in length.

A known device for recoating an optical fibre is produced by Vytran Corp. (1400 Campus Drive West, Morganville, NJ 07751 USA).

The PTR100 model of this device is capable of recoating with an acrylate coating joints of optical fibres or portions of optical fibre from which the coating has been removed.

The portion of bare optical fibre is inserted in a quartz mould, and a pair of fixing devices retains the two ends of the portion of bare fibre in such a way that the fibre is suitably tensioned. The liquid acrylate is injected into the mould and is hardened by exposure to ultraviolet (UV) rays emitted by a UV source. The portion of optical fibre is recoated with a layer of acrylate having a diameter slightly greater than that of the remaining portion of fibre (260 µm instead of 250 µm). The maximum length of the portion of optical fibre which can be recoated with this machine is 51 mm.

US Patent 4662307 held by Corning Glass Works describes a mould for recoating portions of optical fibre or joints between two optical fibres with a UV-sensitive resin. The closed mould has a cavity in which the portion of optical fibre to be recoated is placed. The shape of this cavity is

identical to that of a coated optical fibre, so that the portion of fibre is covered with a layer entirely similar to the original coating.

The mould also comprises a port for the injection of the resin and means for introducing ultraviolet light into the mould in such a way that the resin inside the cavity can be cured and adhere, thus recoating the portion of bare fibre. This patent describes an example in which an optical fibre having a core with a diameter of 125 μm is coated with an acrylate coating with a diameter of 250 μm over a length of 8 mm.

The Applicant has observed that, if the portion of optical fibre to be coated has a length significantly in excess of the limits indicated above, it is difficult to obtain a high concentricity of the bare fibre and coating, since the protection imparted by the coating has to be uniform over the whole length of the fibre. For example, an aperiodic grating (chirped grating) used to compensate the chromatic dispersion undergone by the light impulses after they have passed through a portion of optical fibre line may have a length of as much as approximately one metre. In this case, in order to scribe the grating in the fibre, the fibre has to have its coating removed over the said portion whose length is approximately one metre. The principal problem of the operation of coating such a long portion of optical fibre is that of the concentricity of the coating, since the portion of bare fibre, if retained by a pair of fixing devices at its two ends, develops a downward curvature as a result of its own weight. Furthermore, the length of the mould, corresponding to that of the portion of optical fibre to be coated, should include a plurality of dispensers for applying the acrylate. This structure has limited versatility, since the length of the mould restricts the length of bare fibre which can be reconstructed.

The Applicant has resolved the problem of coating portions

of optical fibre of variable length, particularly portions having lengths of more than 10 cm, for example.

In particular, the Applicant has devised a method and a device for coating a portion of bare optical fibre in which the said portion of bare fibre, and a mould into which the portion of optical fibre to be recoated is inserted, move with respect to each other in such a way as to allow the mould to pass along the whole portion of bare fibre to be coated.

In a first aspect, the invention relates to a method for coating an optical fibre component from which the external coating has previously been removed, comprising the following steps:

- placing the said optical fibre component in a rectilinear position,
- fitting a mould for coating the said component on one end of the component,
- generating a relative movement between the mould and the component, in such a way that the mould passes along the whole length of the component.

Preferably, the said generating step comprises the movement of the said mould from one end of the said fibre component to the other.

Alternatively, the said generating step comprises the sliding of the said fibre component from one of its ends to the other within the said mould.

In particular, the said step of sliding the said fibre component comprises the unwinding of the said component from a first roller on which it is initially wound, and its simultaneous winding on to a second roller.

In a further aspect, the present invention relates to a device for coating an optical fibre component from which the external coating has previously been removed, comprising:

- a mould for coating the said component,
- a pair of fixing elements for retaining the said component in a rectilinear position,

characterized in that it comprises:

a device for the movement of the said mould and the said optical fibre component relative to each other, which enables the mould to pass along the whole length of the component placed in a rectilinear position.

In particular, the said movement device comprises a carriage on which the said mould is fixed, and a slide on which the said carriage slides and is guided. In particular, the said movement device comprises a first roller on which the said optical fibre component is initially wound and a second roller on which the said component is wound after being passed through the inside of the mould.

Preferably, the said carriage is driven by a motor.

Alternatively, the said second roller is driven by a motor.

In particular, the said mould comprises two halves, which are complementary to each other in such a way that they can be placed with one on top of the other and in contact with each other to form, in the central area of the mould, a chamber for the accumulation of the material forming the coating, an entry channel of circular cross section for the insertion of the bare fibre and an exit channel of circular cross section through which the coated fibre emerges from the mould.

In particular, the said entry channel has a diameter slightly greater than that of the bare fibre.

In particular, the said exit channel has a diameter equal to the diameter of the coated fibre.

The said device for coating an optical fibre component

additionally comprises an ultraviolet lamp integral with the said mould, and a dispenser of the material forming the coating, connected to a channel for the introduction of the said material present into the said mould.

Further characteristics and advantages of the present invention can be found in greater detail in the following description, with reference to the attached drawings which are provided solely for the purpose of clarification and without any restrictive intent, and in which are shown:

in Fig. 1, a schematic view of a device for coating a portion of bare optical fibre according to one embodiment of the present invention;

in Fig. 2, a schematic view of a device for coating a portion of bare optical fibre according to an alternative embodiment of the present invention;

in Fig. 3, a longitudinal section through a mould of the device of Figure 1 according to one embodiment of the present invention;

in Fig. 4, a side view of the mould shown in Figure 3.

Figure 1 shows a device 1 for coating a portion of bare optical fibre according to one embodiment of the present invention, comprising a pair of tensioning elements 2 and 2' for a portion of optical fibre 3 from which the coating has been removed, on each of which is placed a fixing element 4 or 4' for each termination of the said fibre 3.

The device also comprises a carriage 5 which can slide on a guide 6 having its ends at the positions of the pair of tensioning elements 2 and 2'.

The said guide is preferably a very high-precision slide (the error of parallelism between the supporting plane and the plane on which the carriage slides is not more than ± 5 μm) with a length of approximately 2 metres.

A mould 7, into which the fibre 3 to be coated is inserted, illustrated in particular in the subsequent Figures 3 and 4, is positioned on the said carriage. The mould is connected to a dispenser 8 for the material in the liquid state which forms the coating. An ultraviolet (UV) lamp 9 is advantageously placed in the proximity of the mould 7 and is preferably integral with the carriage 5.

The carriage 5 is suitably driven by a motor (not shown) and is moved along the guide 6, preferably at a controlled speed, from one end to the other of the portion of fibre 3. Preferably, the carriage is moved by means of an endless screw driven by an external motor. The endless screw rotates about itself and causes the movement of the carriage. The said motor is advantageously a very high-precision motor which does not cause vibrations, provides a constant speed, and reaches the working speed with a constant acceleration when starting and stopping. The value of the acceleration can be preset. The said characteristics of the motor are essential for avoiding vibrations or abrupt movements which might adversely affect the quality of the coating.

Figure 2 shows a device 1 for coating a portion of bare optical fibre according to a further embodiment of the present invention, comprising a pair of rollers 10 and 10' on which are fixed the ends of the portion of fibre 3 to be coated. The device also comprises a mould 7, shown in detail in Figures 3 and 4, mounted on a fixed support 11.

At least one of the said rollers 10 and 10' is driven by a motor (not shown) which enables the optical fibre to be wound on one roller and to slide within the mould 7. In a similar way to the embodiment in Figure 1, the mould 7 is connected to a dispenser 8 for the material in the liquid state which forms the coating. Additionally, an ultraviolet (UV) lamp 9 is advantageously placed in the proximity of the mould 7.

In general, the present invention in one of its aspects provides a device for producing a relative movement of the said mould 7 and the said optical fibre component 3, which enables the mould to pass along the whole length of the component which is placed in a rectilinear position. In the embodiment of Figure 1, this movement device comprises the aforesaid carriage which is moved on the slide from one end to the other of the portion of fibre which forms the said component. In the embodiment shown in Figure 2, this movement device comprises the aforesaid pair of rollers 10 and 10'.

Figures 3 and 4 show in detail the mould 7, comprising two halves 71 and 72, which are preferably complementary to each other in such a way that they can be placed with one on top of the other and in contact with each other. The placing of one half on top of the other forms, in the central area of the mould which is thus created, a chamber 73 for the accumulation of the material forming the coating, an entry channel 74 with a circular cross section for the insertion of the bare fibre, and an exit channel 75 with a circular cross section through which the fibre coated by the mould emerges.

The mould also comprises a channel 77 which introduces the liquid material contained in the dispenser 8 into the accumulation chamber.

Each of the two halves is preferably made from metallic material, or more generally from a material which is practically non-deformable at high temperatures and is capable of preventing the entry of ultraviolet light into the mould.

The channels are positioned in such a way that both have their centres located along the same axis, identified by the letter A in Figure 3, in such a way that the fibre is kept in a rectilinear position. Additionally, the entry channel 74 has a diameter slightly greater than that of the

bare fibre, and the exit channel 75 has a diameter equal to the diameter of the coated fibre. This difference between the two diameters contributes significantly to the reconstruction of a coating whose thickness is as uniform as possible on the core of the fibre. The entry channel 74 also has a flare 76 which facilitates the insertion of the fibre 3 into the mould, in such a way as to avoid an abrupt positioning of the fibre which might cause damage to, or even fracture of, the fibre.

The device shown in Figure 1 operates in the following way.

A portion of fibre from which the coating has been removed is placed on the tensioning elements 2 and 2', and its ends are secured to the fixing elements 4 and 4'.

The portions of fibre from which the coating has not been removed adjacent to the portion of bare fibre are advantageously fixed to the fixing elements, so that the said portion of bare fibre is completely free of restrictions.

The carriage 5 is placed on one end of the guide 6. A first half of the mould is placed on the said carriage in such a way that the fibre 3 without coating is positioned exactly along the axis A. The second half of the mould is placed on top of the first to form the complete mould. In this condition, the fibre is inserted fully into the mould, and the liquid material is released by the dispenser and passes through the channel 77 into the accumulation chamber 73 inside the mould, filling it completely.

An optical fibre is normally protected by a double layer of coating as mentioned above.

In particular, a fibre has

- a primary coating with an external diameter of approximately 180 μm, having low mechanical strength; the principal purpose of this type of coating is to provide good adhesion with the fibre and to dissipate the stresses

caused by any bending;

- a secondary coating with a diameter of approximately 245 μm, having a greater mechanical strength; the purpose of this coating is to protect the fibre from external agents. The tolerances on the external diameter of this coating are very limited, since the fibre may be subjected to further steps of processing (e.g. colouring and deposition).

The device described above for coating a fibre reconstructs a single layer of coating which performs both functions of the two original coatings. It is therefore necessary to use a material capable of performing the two functions of the primary and secondary coatings.

An example of a material suitable for the coating is an acrylic resin having a high rate of cure when subjected to UV rays. This is because the resin should advantageously harden soon after the deposition on the bare fibre. In particular, a suitable resin is one which requires at least 2.1 J/cm^2 of UV energy to reach a high curing level, a density of at least 1110 $kg \cdot m^{-3}$ at 23°C, and a viscosity of at least 7200 mPa/s at 25°C.

A resin used by the Applicant for this purpose is Desolite® 950-131, produced by DSM Desotech.

The carriage driven by the motor is moved at constant speed from one end of the guide to the other, in such a way that the mould passes along the whole of the portion of fibre to be coated.

The device described in Figure 1 is preferably placed in a vertical position; in particular, the bare fibre is placed between the fixing elements 4 and 4', one of which is placed on top of the other, keeping the portion of bare fibre in a vertical position, to prevent the formation of curvature in the portion of fibre to be coated.

The carriage and the mould integral with it preferably move

from the tensioning element located in the lower position to the tensioning element located in the upper position; thus the carriage, during its upward movement, moves progressively away from the coated area of the portion of fibre, which, owing to the force of gravity, tends not to accumulate in the proximity of the output channel.

The speed at which the carriage moves is a very important parameter, since, if the carriage travels at an excessively low speed, some of the acrylate deposited on the fibre might also be deposited on the outer part of the exit channel of the mould, thus adversely affecting the operation of the device.

On the other hand, an excessively high speed of the carriage would produce a non-uniform coating on the fibre.

A carriage speed suitable for the purpose is in the range from 4 mm/s to 6 mm/s, and is preferably 5 mm/s.

During the movement of the carriage, the material which will form the coating continues to flow into the mould through the channel 77. The relative movement between the mould and the fibre enables the fibre emerging from the mould through the exit channel 75 to be coated with a layer whose thickness is practically equal to the diameter of the said exit channel.

The entry channel, having a diameter slightly greater than the diameter of the bare fibre, enables the fibre to remain in the centre of the exit channel at all times, and therefore enables the coating to be positioned in a uniform way along the whole fibre.

The ultraviolet lamp 9 advantageously moves together with the carriage 5 in such a way as to rapidly cure the material emerging from the exit channel around the fibre.

The coating operation is carried out in a time $T_R = L_R/V_C$, where LR is the length of the portion of fibre to be coated

and V_c is the speed at which the carriage moves.

By way of example, the applicant has recoated an optical fibre component, using the device shown in Figure 1 installed vertically.

The said component consists of a chirped grating for compensating chromatic dispersion, formed in an SM (single mode) optical fibre of a commercially available type.

This component has a portion of approximately 1 metre to be coated; the resin used for forming the coating is the aforesaid Desolite® 950-131 produced by DSM Desotech. The UV lamp used is an ultraviolet lamp made by Lumatec, having an emission spectrum corresponding to the absorption spectrum of the said acrylate.

The mould was initially placed in the proximity of a tensioning element located at the base and was then moved vertically along the guide towards the other tensioning element. The temperature at which the resin is introduced into the mould is approximately 25°C. The carriage with its associated mould is moved at a constant speed of approximately 5 mm/s. The time required to carry out the whole coating operation was approximately 200 seconds.

CLAIMS

1. Method for coating an optical fibre component (3) from which the external coating has previously been removed, comprising the following steps:

- placing the said optical fibre component in a rectilinear position,
- fitting a mould (7) for coating the said component on one end of the component,
- generating a relative movement between the mould (7) and the component (3), in such a way that the mould passes along the whole length of the component.

2. Method according to Claim 1, in which the said generating step comprises the movement of the said mould (7) from one end of the said fibre component to the other.

3. Method according to Claim 1, in which the said generating step comprises the sliding of the said fibre component from one of its ends to the other within the said mould.

4. Method according to Claim 3, in which the said step of sliding the said fibre component comprises the unwinding of the said component from a first roller (10') on which it is initially wound, and its simultaneous winding onto a second roller (10).

5. Device for coating an optical fibre component (3) from which the external coating has previously been removed, comprising:

- a mould (7) for coating the said component,
- a pair of fixing elements for retaining the said component in a rectilinear position,

characterized in that it comprises:

a device for the movement of the said mould (7) and the said optical fibre component (3) relative to each other, which enables the mould to pass along the whole length of

the component placed in a rectilinear position.

6. Device for coating an optical fibre component according to Claim 5, in which the said movement device comprises a carriage (5) on which the said mould (7) is fixed, and a slide (6) on which the said carriage slides and is guided.

7. Device for coating an optical fibre component according to Claim 5, in which the said movement device comprises a first roller (10') on which the said optical fibre component is initially wound, and a second roller (10) on which the said component is wound after being passed through the inside of the mould (7).

8. Device for coating an optical fibre component according to Claim 6, in which the said carriage is driven by a motor.

9. Device for coating an optical fibre component according to Claim 7, in which the said second roller (10) is driven by a motor.

10. Device for coating an optical fibre component according to Claim 5, in which the said mould comprises:
- two halves (71, 72), which are complementary to each other in such a way that they can be placed with one on top of the other and in contact with each other to form, in the central area of the mould, a chamber (73) for the accumulation of the material forming the coating,
- an entry channel (74) of circular cross section for the insertion of the bare fibre,
- an exit channel (75) of circular cross section through which the coated fibre emerges from the mould.

11. Device for coating an optical fibre component according to Claim 10, in which the said entry channel (74) has a diameter slightly greater than that of the bare fibre.

12. Device for coating an optical fibre component according to Claim 10, in which the said exit channel (75) has a

diameter equal to the diameter of the coated fibre.

13. Device for coating an optical fibre component according to Claim 5, additionally comprising an ultraviolet lamp (9) integral with the said mould (7).

14. Device for coating an optical fibre component according to Claim 5, additionally comprising a dispenser (8) of the material forming the coating, connected to a channel for the introduction of the said material (77) present in the said mould (7).

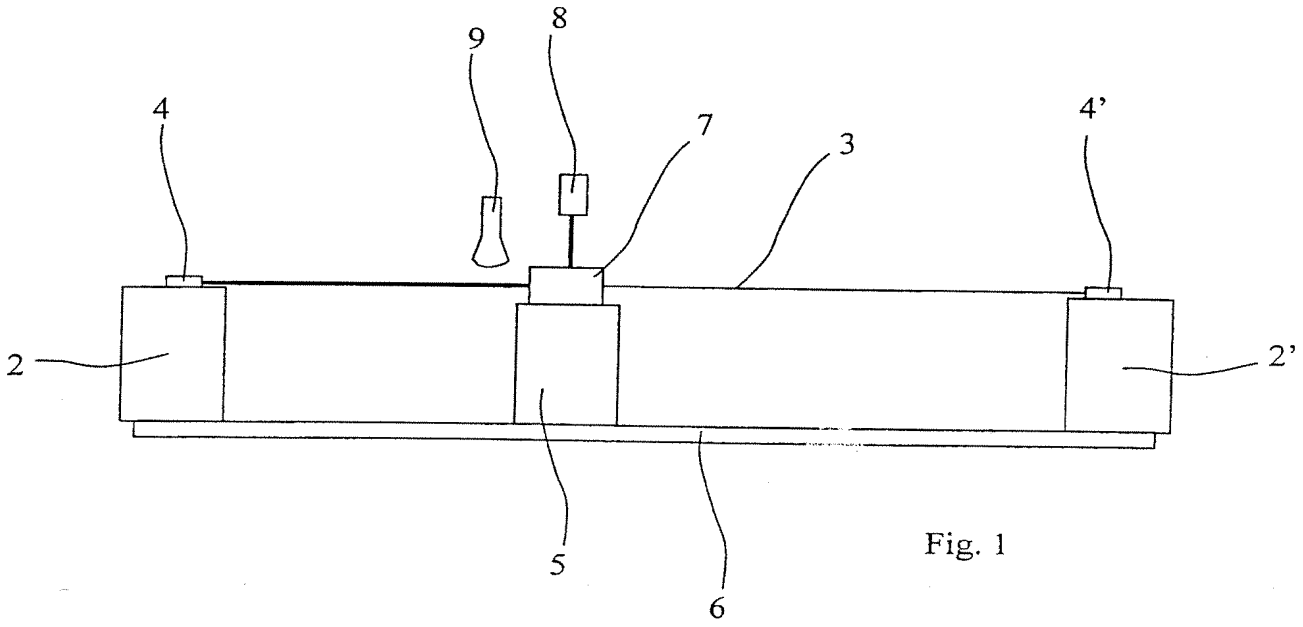

Fig. 1

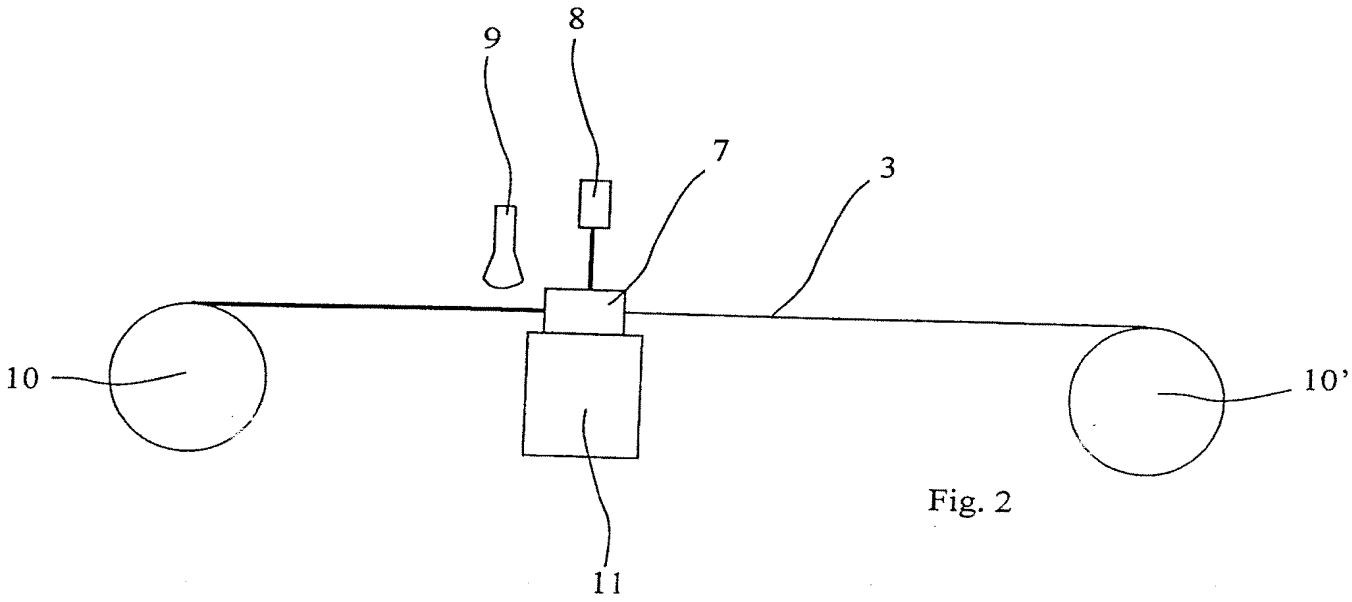

Fig. 2

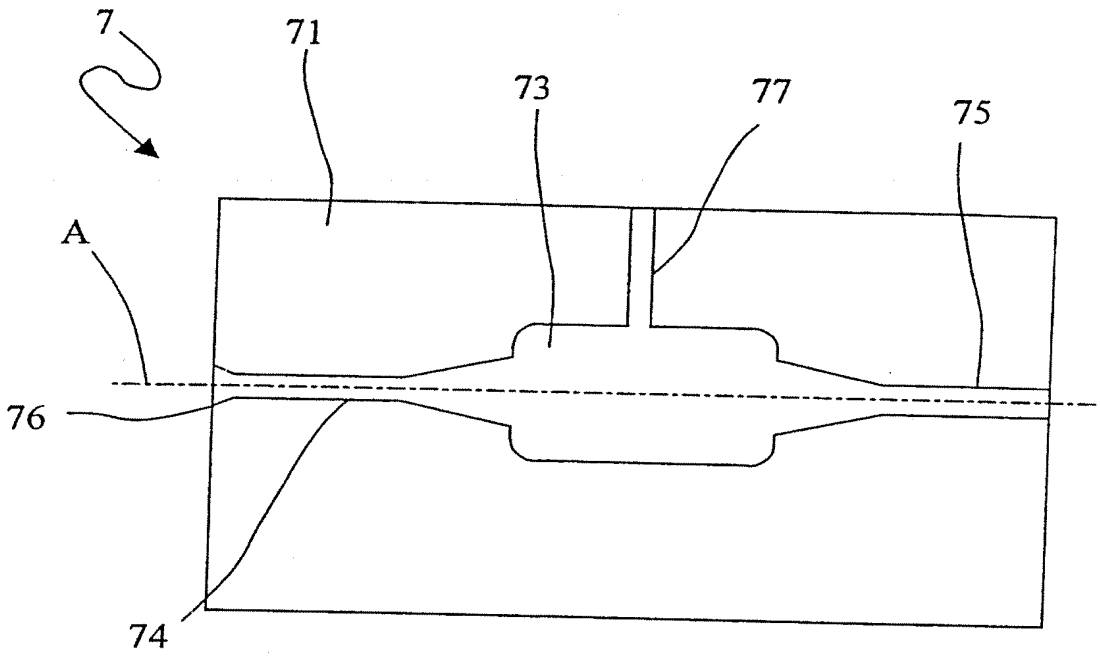

Fig. 3

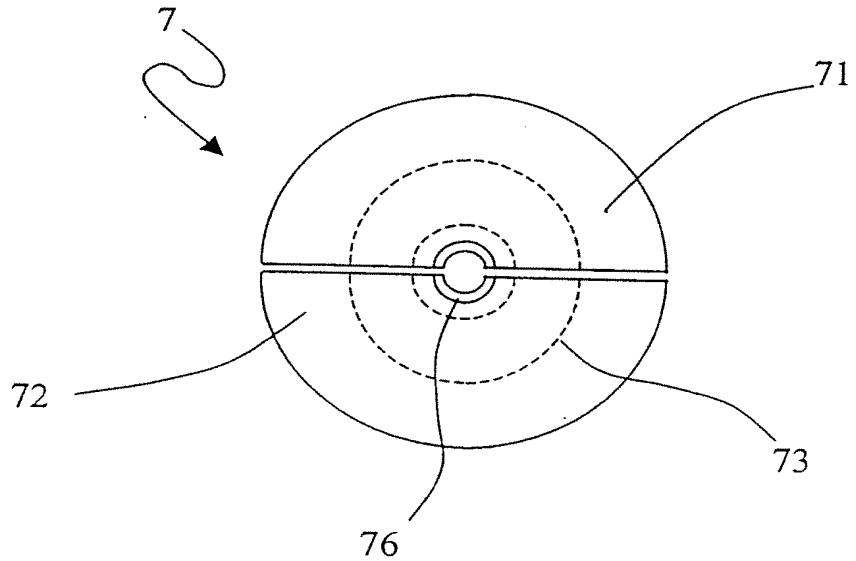

Fig. 4